PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference DC5157PCT1	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/US2004/025050	International filing date *(day/month/year)* 29.07.2004	Priority date *(day/month/year)* 08.08.2003

International Patent Classification (IPC) or national classification and IPC
H01L21/56, H01L23/31, H01L21/58

Applicant
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1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 7 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☒ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
06.01.2005	18.11.2005
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US2004/025050

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-3, 5, 7, 9-13, 15	as originally filed
4, 6, 8, 14	received on 14.03.2005 with letter of 05.03.2005

Claims, Numbers

1-16	received on 14.03.2005 with letter of 05.03.2005

Drawings, Sheets

1-9	as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☒ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☒ the claims, Nos. 10
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US2004/025050

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-16
	No:	Claims	1,2
Inventive step (IS)	Yes:	Claims	
	No:	Claims	3-16
Industrial applicability (IA)	Yes:	Claims	1-16
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

SECTION I

1. It is not evident where the expression "optically clear material" in claim 10 originates.

SECTION V

1. Reference is made to the following documents:

   D1: US-A-2003145940
   D2: US-A-20020110956
   D3: US-A-5592025

2. D1 discloses (see [57] - [70]) a method comprising all of the features of claim 1, as well as the additional features of claim 2. The examiner notes that step g) of claim 1 is suggested in [0068] of D1.

3. D2 discloses (see Figs.2 and [29] - [43]) a method comprising all of the features of claim 7 apart from the use of a curable silicone resin (semiconductor device 101; mold 120,130; heating the mold; injection molding curable liquid 150).
   This feature is, however, an obvious variation for the skilled person in view of the passage at [0036] - [0038] and the teaching of D3.

   D2 also discloses the additional features of claims 11,12,13,14 (see Table 1) and 16.

4. D3 is also relevant for the claims. Figs.5,6 and Col.4, l.54 - Col.5, l.27) disclose all of the features of claim 1 apart from the details of the die adhesive 51. The skilled person would then employ the adhesive in the manner described in D1 and thereby arrive at the subject-matter of claim

1 without an inventive step.
The additional features of claims 2 and 3 follow directly from the combination of D3 and D1.

5. Claims 8,15: D3 discloses all of the features of these claims apart from the details of the transfer molding. These details are, however, generally known to the skilled person - see D2.

6. Claims 4,5,8,9,10: D3 is silent on the process details of the transfer moulding, mentioning merely the possibility of using a silicone resin. Hence the skilled person would look to the prior art for such details. D2 (see [29] - [43]) indicates desirable parameters for transfer moulding that the skilled person would advantageously select for a silicone sealing resin.
The examiner notes that the applicant has employed commercially available silicone resins in the examples. Hence the skilled person selecting such resins would also arrive at the claimed parameters.

SECTION VIII

1. The presence of a plurality of independent claims in the same category means that the claims as a whole are not concise. In the present case a single independent claim in any category is appropriate.

CLAIMS

1. A method comprising:

a) applying a die attach adhesive composition to a substrate,

b) curing the die attach adhesive composition to form a die attach adhesive,

c) plasma treating a surface of the die attach adhesive,

d) plasma treating a surface of a semiconductor die,

e) contacting the plasma treated surface of the semiconductor die with the plasma treated surface of the die attach adhesive,

optionally f) wire bonding the semiconductor die to the substrate,

g) injection molding a curable liquid over the product of step f),

optionally h) forming solder balls on a surface of the substrate opposite the die attach adhesive.

2. The method of claim 1, where the die attach adhesive comprises a silicone die attach adhesive.

3. The method of claim 1, where the curable liquid comprises a silicone composition.

4. The method of claim 3, where the silicone composition cures to form an over mold having a modulus of 25 to 1,000 megaPascals, and where the silicone composition has a viscosity of 80 to 3000 Poise and a curing profile such that the silicone composition cures in 30 to 120 seconds at a temperature of 80 to 240 °C.

5. The method of claim 4, where step g) comprises:

i) placing the product of step e) or the product of step f) in an open mold,

ii) closing the mold to form a mold cavity,

iii) heating the mold cavity,

iv) injection molding a curable liquid into the mold cavity to overmold the semiconductor die on the substrate,

v) opening the mold and removing the product of step iv), and

optionally vi) post-curing the product of step v).

6. An electronic component comprising

a substrate,

a die attach adhesive on a surface of the substrate,
a semiconductor die attached to the die attach adhesive,
optionally a wire bond connecting the semiconductor die to the substrate,
an overmold over the semiconductor die, and
optionally o solder balls on a surface of the substrate opposite the die attach adhesive;
where the electronic component is prepared by the method of claim 1.

7. A method comprising:
i) placing a semiconductor device in an open mold,
ii) closing the mold to form a mold cavity,
iii) heating the mold cavity,
iv) injection molding a curable liquid comprising a silicone composition into the mold cavity to overmold the semiconductor device,
v) opening the mold and removing the product of step iv), and
optionally vi) post-curing the product of step v).

8. The method of claim 7, where the semiconductor device comprises a substrate, a die attach adhesive, and an integrated circuit, wherein the integrated circuit is attached to a surface of the substrate through the die attach adhesive, and where the integrated circuit is wire bonded to the surface of the substrate,

9. The method of claim 7, where step ii) is carried out by applying a clamping force of 1 to 27 tons.

10. The method of claim 7, where the silicone composition forms an optically clear material upon cure.

11. The method of claim 7, where step iii) is performed at a temperature of 80 to 180 °C.

12. The method of claim 7, wherein step iv) is carried out at an injection speed sufficient to provide a pressure of 0.6 to 2.0 MPa force in the mold cavity.

13. The method of claim 10, where the silicone composition has a viscosity of 80 to 3000 Poise.

14. The method of claim 10, where a cured product of the silicone composition has a modulus of 100 to 1,000 megaPascals.

15. A method comprising:

a) applying a die attach adhesive composition to a substrate,

b) attaching a semiconductor die to the die attach adhesive composition,

c) curing the die attach adhesive composition to form a die attach adhesive,

optionally d) wire bonding the semiconductor die to the substrate, and

e) injection molding a curable liquid over the semiconductor device formed as the product of step c) or step d), wherein injection molding is carried out by a method comprising

i) placing the semiconductor device in an open mold,

ii) closing the mold to form a mold cavity,

iii) heating the mold cavity,

iv) injection molding a curable liquid into the mold cavity to overmold the semiconductor device,

v) opening the mold and removing the product of step iv), and

optionally vi) post-curing the product of step v).

16. A method comprising:

a) attaching a semiconductor die to a substrate to form a semiconductor device, and

b) injection molding a curable liquid over the semiconductor device by a method comprising

i) placing the semiconductor device in an open mold,

ii) closing the mold to form a mold cavity,

iii) heating the mold cavity,

iv) injection molding a curable liquid comprising a silicone composition into the mold cavity to overmold the semiconductor device,

v) opening the mold and removing the product of step iv), and

optionally vi) post-curing the product of step v).

DRAWINGS

[0064] Figure 1 is a schematic representation of liquid injection molding process equipment for use in the method of this invention.

[0065] Figure 2a is a cross sectional view taken along line 108 of a mold 106 for use in the liquid injection molding process equipment 100 in Figure 1. Figure 2a shows the mold 106 in its open position. Figure 2b is the mold 106 shown in its closed position.

[0066] Figure 3a is a cross sectional view taken along line 108 of an alternative mold 106 for use in the liquid injection molding process equipment 100 in Figure 1. Figure 3a shows the mold in its open position. Figure 3b is the mold 106 in its closed position.

[0067] Figure 4a is a cross sectional view taken along line 108 of an alternative mold 106 for use in the liquid injection molding process equipment 100 in Figure 1. Figure 4a shows the mold in its open position. Figure 4b shows the mold 106 in the closed position.

[0068] Figure 5 is a cross sectional view taken along line 109 of a mold 106 according to Figure 1.

[0069] Figure 6 shows a cross sectional view taken along line 109 of a mold 106 according to Figure 1.

[0070] Figure 7 shows an electronic component 700 fabricated by the process of this invention.

[0071] Figure 8 shows an alternative electronic component made by the process of this invention.

[0072] Figure 9 shows an alternative electronic component 900 fabricated by the process of this invention.

Reference Numerals

100	liquid injection molding process	109	cross section line
101	feed system	201	first section
102	feed tank	202	second section
103	feed tank	203	mold retainer
104	static mixer	204	substrate
105	extruder	205	semiconductor dice
106	mold	206	mold cavities
107	inlet	210	sprue
108	cross section line	211	runner system

krypton, neon, nitrogen, nitrous oxide, oxygen, ozone, water vapor, combinations thereof, and others. Alternatively, other more reactive gases or vapors can be used, either in their normal state of gases at the process application pressure or vaporized with a suitable device from otherwise liquid states, such as hexamethyldisiloxane, cyclopolydimethylsiloxane, cyclopolyhydrogenmethylsiloxanes, cyclopolyhydrogenmethyl-co-dimethylsiloxanes, reactive silanes, and combinations thereof.

[0020] Die attach may be carried out by

a) plasma treating a surface of the die attach adhesive,

b) plasma treating a surface of the semiconductor die, and

c) thereafter contacting the plasma treated surface of the semiconductor die with the plasma treated surface of the die attach adhesive. The die attach adhesive may be contacted with the semiconductor die as soon as practicable after plasma treatment. Alternatively, the method may optionally further comprise: storing the die attach adhesive after step a) and before step c), or storing the semiconductor die after step b) and before step c), or both.

[0021] Steps a) and b) may be carried out concurrently or sequentially in any order. Plasma treatment can be carried out on all or a portion of the surface of the die attach adhesive or the semiconductor, or both.

[0022] The die attach adhesive can be stored for at least 0, alternatively at least 1, alternatively at least 2 hours after plasma treatment. The die attach adhesive can be stored for up to 48, alternatively up to 24, alternatively up to 8, alternatively up to 4 hours after plasma treatment. The same storage conditions can be used independently for the die attach adhesive and the semiconductor.

[0023] Adhesion can be obtained by carrying out step c) for a few seconds at room temperature. Alternatively, step c) may be carried out at elevated temperature, elevated pressure, or both. The exact conditions selected for step c) will depend on various factors including the specific use of the method. However, temperature during the contacting step can be at least 15 °C, alternatively at least 20 °C, alternatively at least 100 °C. Temperature during contacting can be up to 400 °C, alternatively up to 220 °C. Pressure during contacting can be up to 10 megaPascals, alternatively up to 1 megaPascal. Pressure during contacting is at least 0.1 megaPascal. Contact time can be at least 0.1 second, alternatively at least 1 second, alternatively at least 5 seconds, alternatively at least 20 seconds. Contact time can be

an organopolysiloxane having an average of at least two alkenyl groups per molecule, (B) an organohydrogenpolysiloxane having an average of at least two silicon atom-bonded hydrogen atoms per molecule, and (C) a hydrosilylation catalyst. The addition reaction curable liquid silicone composition may further comprise one or more optional ingredients selected from (D) a filler, (E) a treating agent for the filler, (F) a catalyst inhibitor, (G) a solvent, (H) an adhesion promoter, (I) a photosensitizer, (J) a pigment, (K) a flexibilizer, and combinations thereof.

[0029] Component (D) is a filler. Suitable fillers include reinforcing fillers such as silica (*e.g.*, fumed silica, fused silica, and ground silica), titania, and combinations thereof. Alternatively, component (D) may be thermally conductive, electrically conductive, or both. Alternatively, component (D) may comprise a combination of conductive and nonconductive fillers. Component (D) may comprise DRAM grade filler or a mixture of DRAM-grade filler and filler of a lesser purity than DRAM grade filler. Component (K) may comprise a long chain alpha-olefin, *e.g.*, an olefin with 14 or more carbon atoms.

[0030] The curable liquid may be a one-part composition or a multiple-part composition such as a two-part composition. When an addition reaction curable liquid silicone composition is formulated as a one-part composition, a hydrosilylation catalyst inhibitor (F) may be included. When an addition reaction curable liquid silicone composition is formulated as a multiple-part composition, any Si-H containing ingredients are stored separately from any hydrosilylation catalyst.

[0031] The curable liquid is formulated to have a viscosity that will minimize wire sweep under the liquid injection molding conditions. Without wishing to be bound by theory, it is thought that viscosity that is too high will contribute to wire sweep, however, viscosity that is too low may allow the curable liquid to leak from the mold. For some addition reaction curable liquid silicone compositions viscosity may be 80 to 3,000 Poise.

[0032] The curable liquid may be formulated to have a cure speed that will minimize wire sweep under the liquid injection molding conditions. Without wishing to be bound by theory, it is thought that a cure speed that is too fast may contribute to wire sweep, however, cure speed that is too slow may render the process inefficient. For some addition reaction curable liquid silicone compositions, cure speed may be 30 to 120 seconds at 80 to 240 °C, alternatively 30 to 60 seconds at 80 to 180 °C, alternatively 30 to 60 seconds at 80 to 150 °C.

80, alternatively 1 to 27 tonnes to the mold, alternatively 10 to 25 tonnes. Step iii) may be performed at a time and temperature of 30 to 120 seconds at 80 to 240 °C, alternatively 30 to 60 seconds at 80 to 180 °C, alternatively 30 to 60 seconds at 80 to 150 °C.

[0036] Step iv) may be carried out at an injection speed sufficient to provide a pressure of 0.3 to 7.0 MPa in the mold cavity. Step iv) may be performed using commercially available liquid injection molding equipment, such as a liquid injection molding apparatus, Model No. 270S 250-60, from Arburg, Inc., of Newington, CT, U.S.A with a mold available from Kipe Molds, Inc., of Placentia, CA, U.S.A. The exact configuration of the liquid injection molding equipment depends on various factors including the exact configuration of the mold and the semiconductor device.

[0037] Figure 1 is a schematic representation of liquid injection molding process equipment 100 for use in the method of this invention. The liquid injection molding process equipment 100 includes a feed system 101 for the two parts of a two part curable liquid silicone composition, as described above. The two parts are fed from the feed tanks 102, 103 to static mixer 104, which mixes the two parts. The resulting curable liquid silicone composition enters extruder 105 and is forced into a mold 106 through an inlet 107 to a sprue and runner system (not shown). The mold 106 may have various configurations, as discussed below and shown in Figures 2a-4b, which represent cross sectional views taken along cross section line and 108 and Figures 5-6, which represent cross sectional views taken along cross section line 109.

[0038] Alternatively, a one part curable liquid can be fed directly into extruder 105 from feed tank 102 (bypassing the static mixer 104).

[0039] Figure 2a is a cross sectional view taken along line 108 of a mold 106 for use in the liquid injection molding process equipment 100 in Figure 1. Figure 2a shows the mold in its open position. The mold 106 is a three part mold in which the first section 201 houses the inlet 107 and the sprue 210. The second section 202 houses the runner system 211. The third section is a mold retainer 203 that holds the substrate 204 having semiconductor dice 205 attached to the surface of the substrate 204 in mold cavities 206. The curable liquid enters the mold cavities 206 at the tops of the semiconductor dice 205 through gates 207. Figure 2b is the mold 106 in Figure 2a shown in its closed position. The mold 106 in Figures 2a and 2b includes heaters (not shown) for the runner system 211.